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Priority Paper

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

ATTORNEY DOCKET NO. 085874/0136

Applicant: Graham BANK et al.

Title: LOUDSPEAKERS

Appl. No.: 09/384,419

Filing Date: August 27, 1999

Examiner: Unassigned

Art Unit: 2743

CLAIM FOR CONVENTION PRIORITY

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

The benefit of the filing date of the following prior foreign application filed in the following foreign country is hereby requested, and the right of priority provided in 35 U.S.C. §119, is hereby claimed.

In support of this claim, filed herewith is a certified copy of said original foreign application:

Japanese Patent Application
No. 9818719.8 filed August 28, 1998.

Respectfully submitted,

November 8, 1999
Date

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Registration No. 28,163

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The Patent Office

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The Patent Office
Concept House
Cardiff Road
Newport
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NP10 8QQ

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P01/7700 25.00 - 9818719.8

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The Patent Office

Cardiff Road
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1. Your Reference — P.5951 — 28 AUG 1998

2. Patent application number *(The Patent Office will fill in this part)* — **9818719.8**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

NEW TRANSDUCERS LTD
Stonehill
Huntingdon
CAMBS PE18 6ED

THE PATENT OFFICE
A
28 AUG 1998
RECEIVED BY FAX

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation — GB

7133119003

4. Title of the invention

VIBRATION EXCITER

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

MAGUIRE BOSS
5 Crown Street
St. Ives
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PE17 4EB

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Country	Priority application number *(if you know it)*	Date of filing *(day/month/year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day/month/year)*

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a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
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Drawing(s)	4

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Request for preliminary examination and search (*Patents Form 9/77*)	
Request for substantive examination (*Patents Form 10/77*)	
Any other documents (*please specify*)	

11. I/We request the grant of a patent on the basis of this application.

Signature Maguire Boss Date 28/08/98

MAGUIRE BOSS

12. Name and daytime telephone number of person to contact in the United Kingdom PAUL J EVENS Tel: 01480 301588

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TITLE: VIBRATION EXCITER

DESCRIPTION

TECHNICAL FIELD

The invention relates to vibration exciters. More particularly, but not exclusively, the invention relates to vibration exciters for exciting resonance in acoustic radiators, e.g. for loudspeakers of the kind described in our International patent application WO97/09842.

BACKGROUND ART

A known form of exciter used to drive a distributed mode loudspeaker panel is based on converting an electrical input into a force which is applied normal to the panel surface. This generates bending waves which emanate from the drive point. By suitable positioning this point the modes in the panel can be arranged to be sufficiently dense to make the panel act as a loudspeaker.

A disadvantage of this method of panel excitation is that it is often necessary for the force to be applied near to the central portion of the panel, which would, for example, be impractical for a transparent panel.

Bending waves derived from a typical force exciter also cause whole body modes, whose radiated sound field interfere with a boundary placed parallel to, and in close proximity with the rear of the panel.

DISCLOSURE OF INVENTION

According to the invention, a vibration exciter for introducing bending waves into a resonant member, e.g. an acoustic radiator panel, comprises means applying torsion to the member. The torsion applying means may be arranged to apply an alternating couple to a local region of the member. The exciter may be inertial.

The torsion applying means may comprise a parallel pair of current carrying conductors fixed to the member and disposed parallel to the plane of the resonant member. Thus a magnetic field applied normal to the current and also in the plane of the member but at right angles to the direction of the current flow will result in rotation of the two current carrying conductors to produce a torsional moment or couple directly in the resonant member.

The preferred position of such a torsional exciter on the resonant member can be expected to be different from that of a force exciter, in that a torsional exciter will inject rotation into the resonant member as opposed to displacement. This has the advantage that no whole body

motion is produced directly, as well as having an optimum exciter location at a point where maximum rotation of the panel is usually encountered. Such a position will often be where the corresponding minimum displacement occurs when using force excitation normal to the panel surface. The torsional exciter is therefore likely, but not necessarily, to be positioned near to the edge of the resonant member. Such a location may be advantageous for those cases where the resonant member needs to have an unobstructed central region.

Other transducer types which may be employed in the direct injection of a torsional or bending moment or couple into the acoustic member include piezoelectric elements. In the piezoelectric effect, a substrate is caused to change length by application of an electric field. It can be arranged that this change in length is orientated from end to end to give a bender type device. Two elements can be cemented back to back to form a bimorph, which will increase the displacement and improve linearity. However, the piezoelectric element can be orientated diagonally corner to corner, for example, in a square piezoelectric element. The element will therefore change shape, and will behave as a twister. Two back to back correctly orientated elements can also form a bimorph twister device.

In another embodiment, the torsion applying means may comprise an element rigidly coupled to and projecting away from the resonant member, and means to induce bending

moments in the element. The bending moments may be produced by displacements in a part of the element spaced from the resonant member, the displacements being perpendicular to the direction in which the element projects from the resonant member. The displacements may be effected using a piezoelectric device. For example, the piezoelectric device may be attached to the part of the element spaced from the resonant member and to a part of the resonant member spaced from the element/resonant member coupling. Operating the piezoelectric device produces extensions and/or contractions which produce the bending moments in the element. The element may extend through and project from opposed surfaces of the resonant member, thereby enabling bending moment inducing means to operate in tandem on either side of the resonant member.

BRIEF DESCRIPTION OF DRAWINGS

The invention is diagrammatically illustrated, by way of example, in the accompanying drawings, in which:-

Figure 1a is an exploded perspective view of a first embodiment of electromechanical torsional vibration exciter;

Figure 1b is a perspective view of a second embodiment of electromechanical torsional vibration exciter;

Figure 1c is an end view of the exciter of Figure 1b;

Figure 1d comprises two diagrams showing steps in the formation of a voice coil for the exciter of Figure 1b;

Figure 2 is a perspective view showing the exciter of

Figure 1b attached to a resonant panel to be vibrated;

Figure 3a comprises two diagrams showing steps in the construction of a piezo bimorph torsional vibration exciter;

Figure 3b is a view in the direction of arrow 'A' of Figure 3a;

Figure 3c is a view in the direction of arrow 'B' of Figure 3a;

Figure 4a is a perspective view of a piezo bimorph torsional vibration exciter fixed to a ground;

Figure 4b is a view in the direction of arrow 'C' of Figure 4a;

Figure 4c is a view in the direction of arrow 'D' of Figure 4a;

Figure 5a in a cross-sectional view of a further embodiment of an electromechanical torsional vibration exciter; and

Figure 5b is a perspective view of the embodiment shown in figure 5b.

BEST MODES FOR CARRYING OUT THE INVENTION

Figure 1a shows a first embodiment of electromechanical torsional vibration exciter of the invention comprising a voice coil and a magnet system and being of the inertial kind. A coil is wound onto a former 1 which is flattened and elongated to form two parallel windings 2. The magnetic system is formed from a permanent bar magnet 3 having a North Pole 4 and corresponding South Pole 5, with a central pole located

between the two and supported on a non-magnetic spacer 6. The central pole and magnet are sandwiched between side plates.

Since the exciter is a torsional device, the axis of rotation is in the plane of the panel to ensure that no unwanted moments are applied. A sufficient clearance between coil and magnet assembly must be provided to allow sufficient angular rotation between the two to occur.

As shown the coil is fixed by its opposite sides in a slot or aperture in the panel, and since the flux needs to pass through the coil, sections of the North and South Pole side plates are removed to form notches accommodating the coil/panel fixings. These fixings comprise taps extending inwards from the slot to contact the voice coil. The taps can be fixed to the voice coil by adhesive means. The magnet can be attached to the panel with a simple suspension means, e.g. resilient means (not shown) and the magnet can, if desired, also be fixed to a reference ground.

An alternative embodiment of inertial torsional vibration exciter which reduces shear in the coil former is shown in Figure 1b,1c,1d and 2 where the coil is mounted on a cylindrical former tube. This reduces the effects of shear by winding the coil along a tubular former 10. A flexible printed circuit could also form the windings. PADDICK, U.S. Patent 5,446,979 shows such a method for conventional circular voice coils, but in this application we would use the method for winding the

conductor along the length of the tubular former. The magnetic circuit is formed by a permanent magnet 13, connected to outer pole pieces forming a North Pole 14 and South Pole 15 whilst the central cylindrical pole 16 is held in place by a non-magnetic spacer 12, fixed to the side of the magnet 13.

As shown in Figure 1c and 2, the exciter is mounted in a slot in a panel with opposite sides of the coil former 17 fixed to the panel to apply an alternating couple thereto when a signal is applied to the coil. The magnet system may be mounted on a resilient suspension (not shown) such that the device operates as an inertial exciter due to the mass of the magnet system.

Figures 3a,3b and 3c show an embodiment of torsional vibration exciter comprising a bimorph piezoelectric bender having a top element orientated such that an applied voltage causes it to contract, as shown, and a bottom element orientated such that it expands, the top and bottom elements being cemented together to form a bimorph bender with a resulting twisting action. This exciter might be used directly on the panel to excite the panel to resonate, but a further refinement could be to ground one end of the bimorph as shown in Figures 4a, 4b and 4c where the twisting now occurs at the ungrounded end, but the magnitude is doubled. This ground could take the form of a substantial frame, or may be an inertial mass.

It is also possible to introduce torsion into the

panel by using a pair of piezoelectric elements, with them set at an angle, connected to the opposite ends of a lever, which is fixed normal to the panel, extending on both sides.

Figure 5a shows a panel, with a lever (18) extending through the panel. A piezoelectric element (19), which will increase in length when a voltage is applied to its electrodes is attached to upper end of lever (18), with its opposite end connected to an inertial mass (21) embedded on the panel. A second piezoelectric element (20) is located on the opposite side of the panel, and is electrically connected in opposition to the first, such that a voltage applied to its electrodes causes it to shorten. On end of element (20) is connected to the lower end of the lever, the other to the inertial to the inertial mass (21). The two actions together produce a moment, which introduces bending waves into the panel. A reference point is provided either by the inertial mass (21), or a connection is made to ground, providing a reference point.

The lever exciter is located with respect to the panel to introduce the maximum rotation, as well as the optimal modal density. This could be completely let into the panel, as shown in Figure 5b, or attached at or near to the edge of the panel. A number of such exciters could be arranged to introduce bending waves in concert to improve modal density.

INDUSTRIAL APPLICABILITY

The invention describes a new class of vibration exciters working in torsion and which exhibit possible advantages over force exciters in their ability to operate at different locations on a member to be vibrated as compared to force exciters and in their ability to prevent or reduce whole body movement of the member to be vibrated.

Figure 1a.

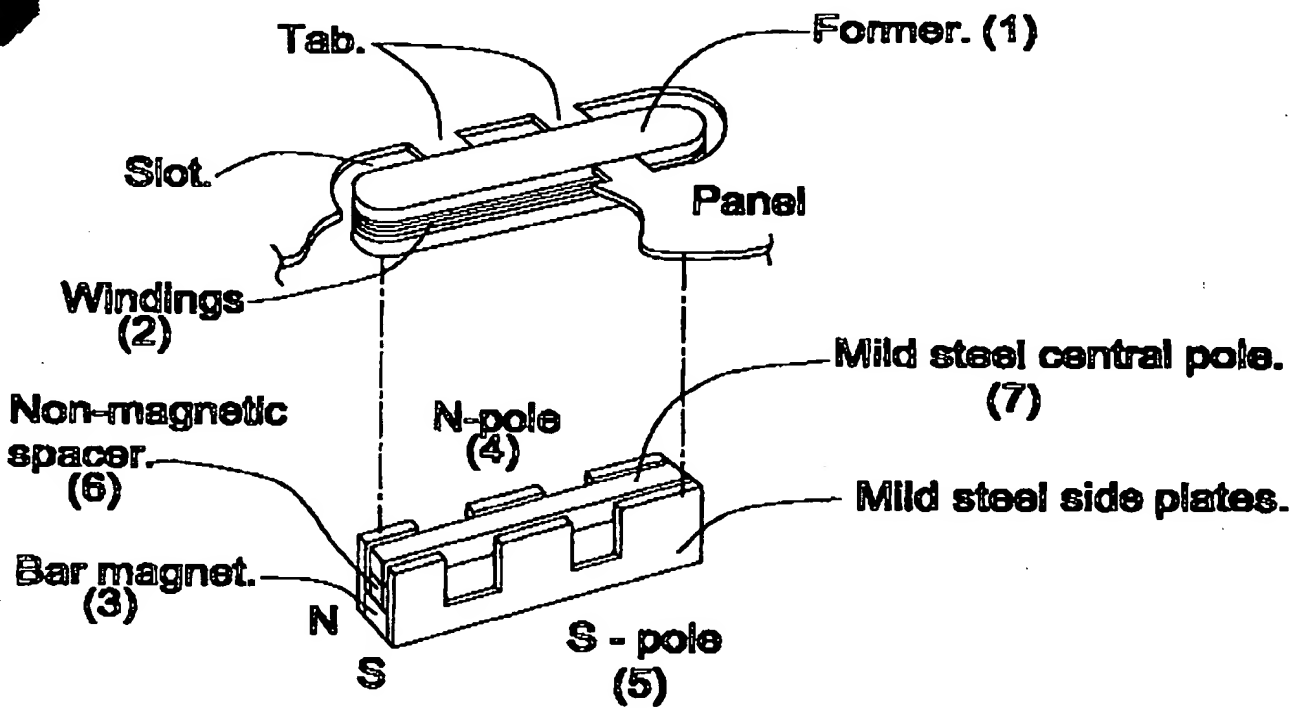


Figure 1b.

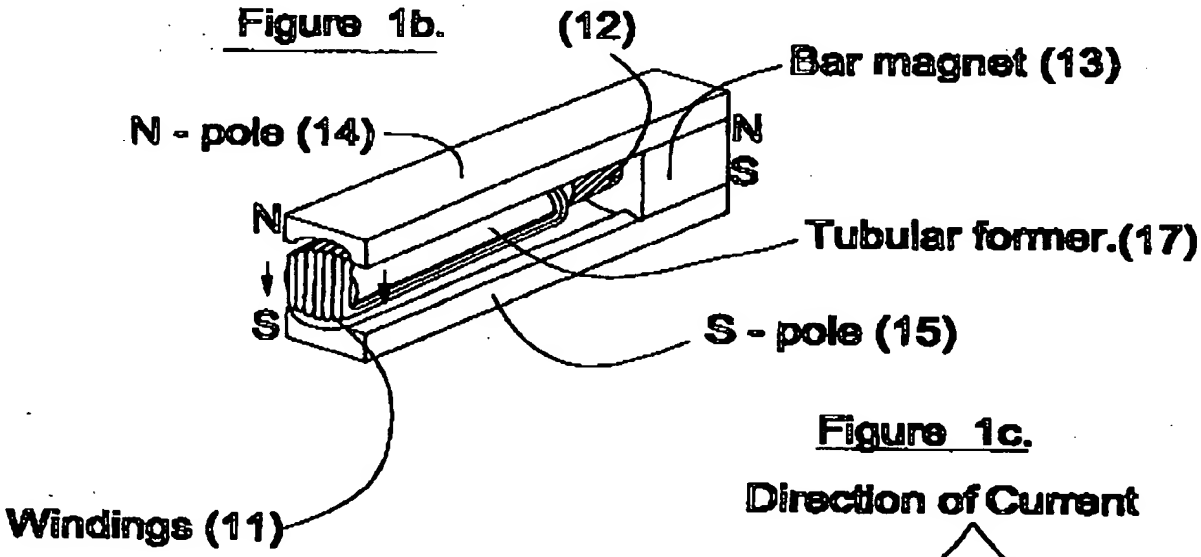


Figure 1c.

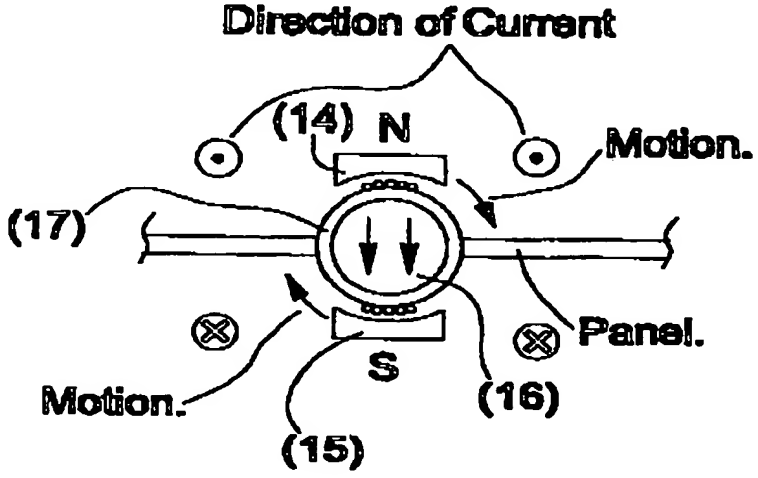
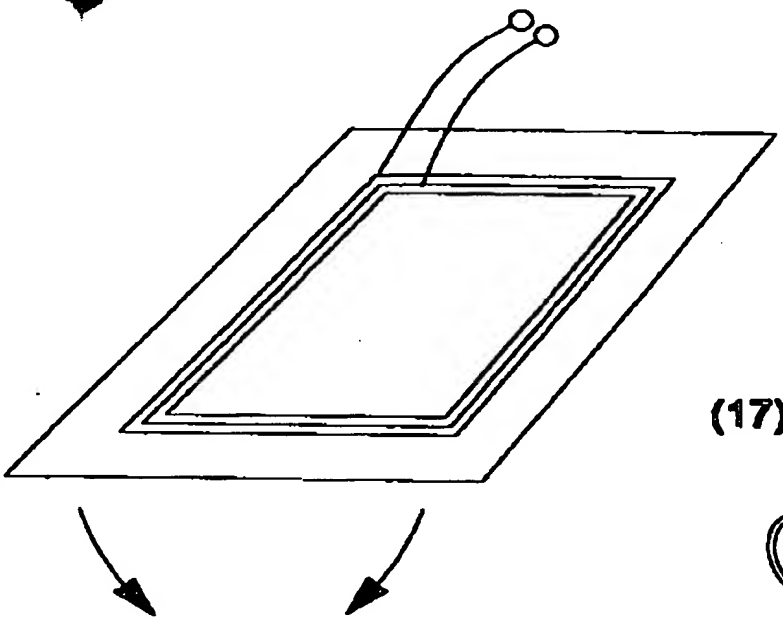
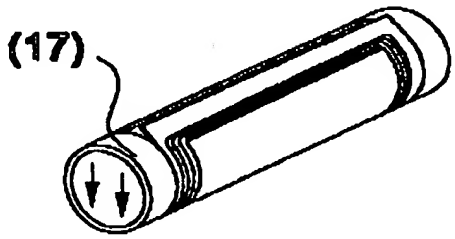


Figure 1d.



Flat winding wrapped up to form tube.



Windings on tubular former.

Figure 2.

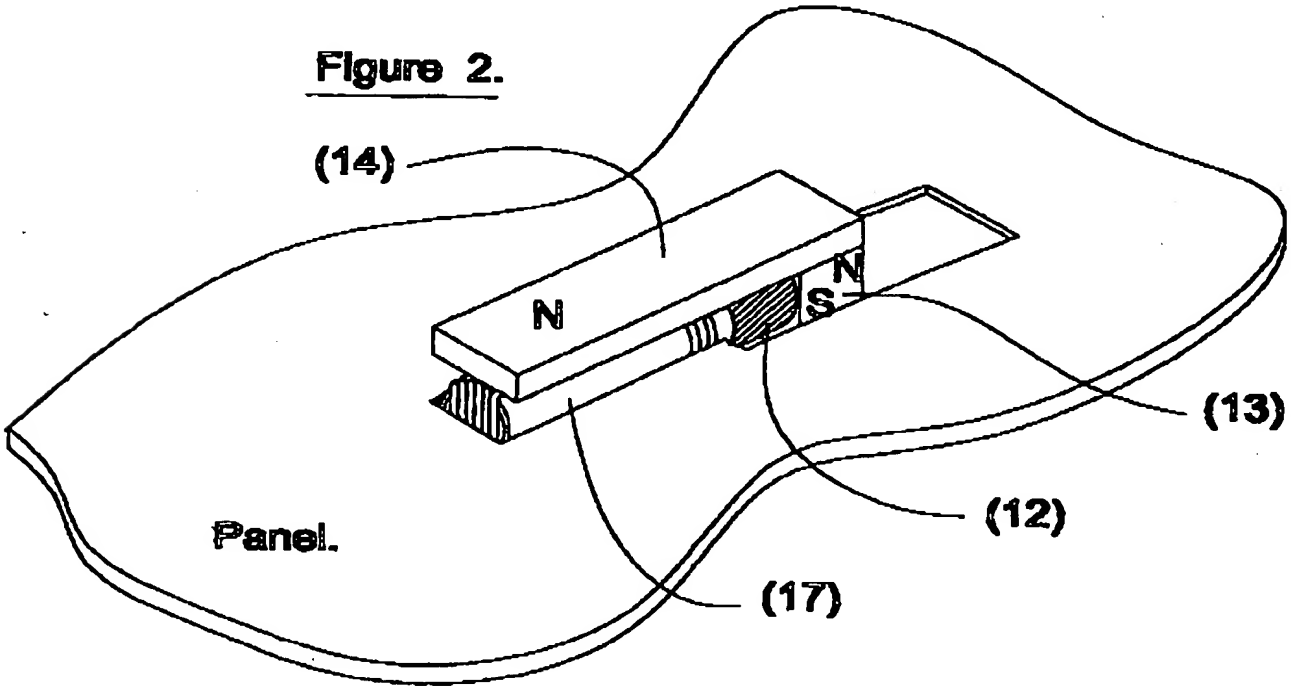


Figure 3a.

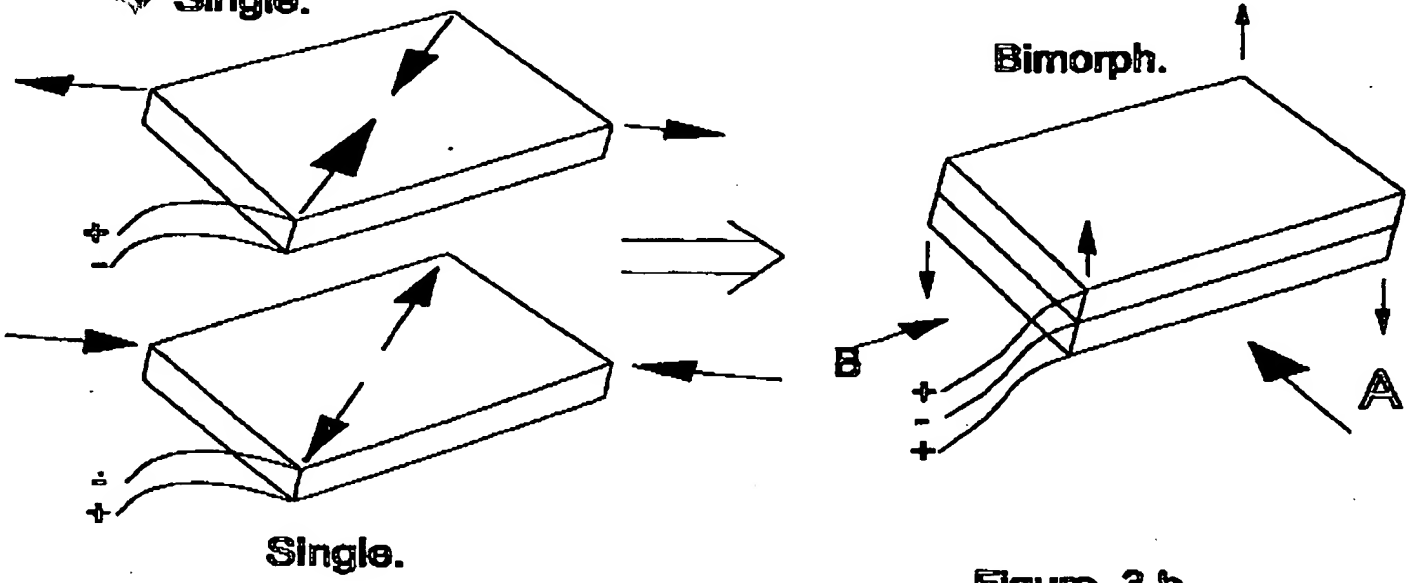
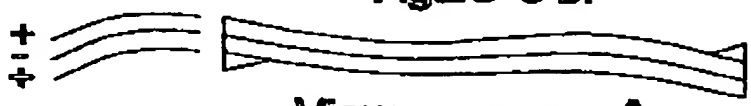


Figure 3 b.



View on arrow. A

Figure 4.a

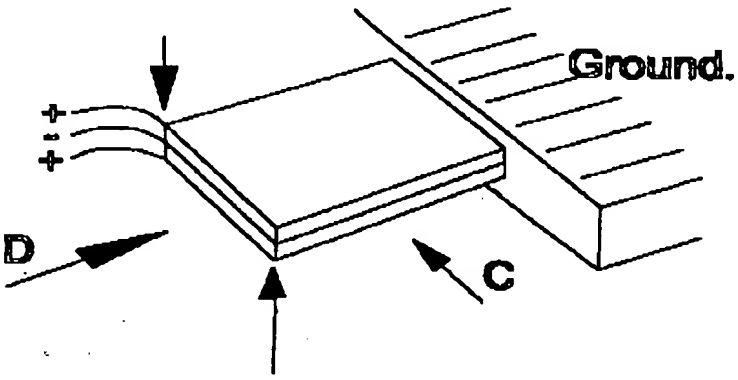
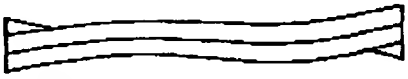
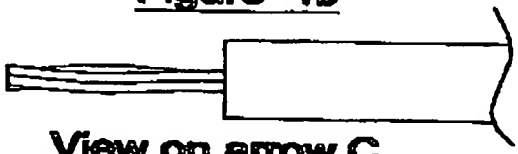


Figure 3c



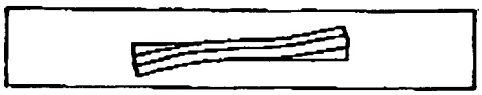
View on arrow.B

Figure 4b



View on arrow C

Figure 4c.



View on arrow D.

Figure 5a.

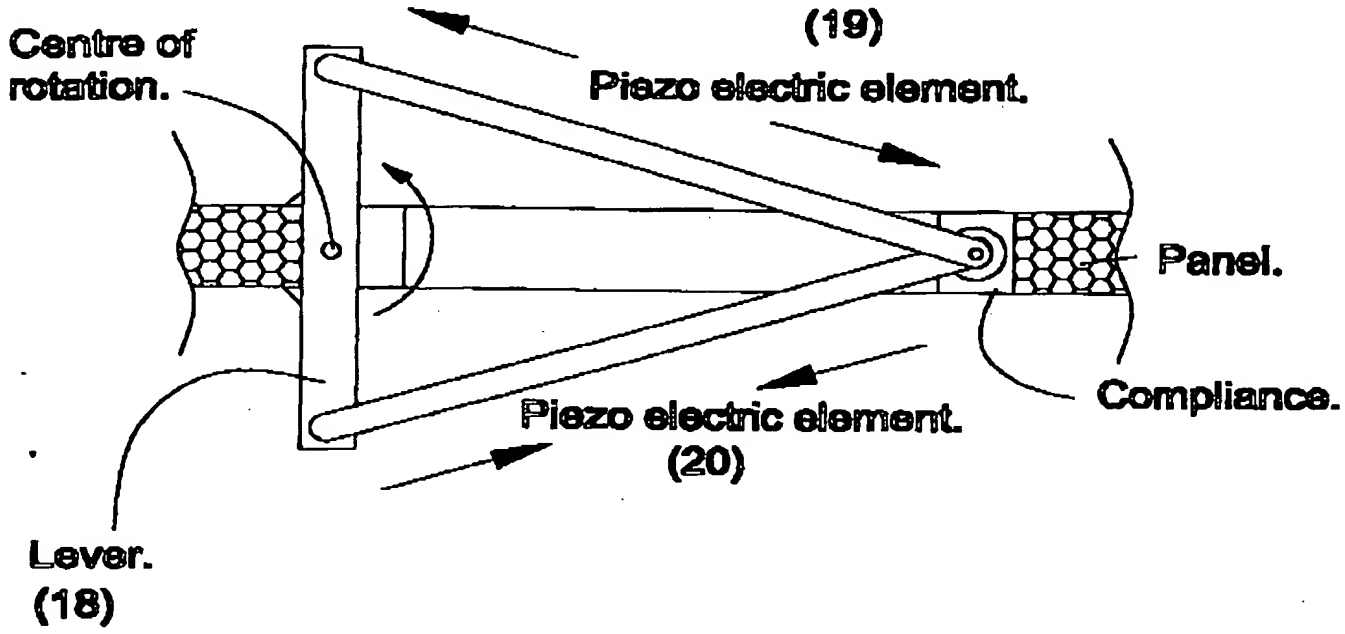
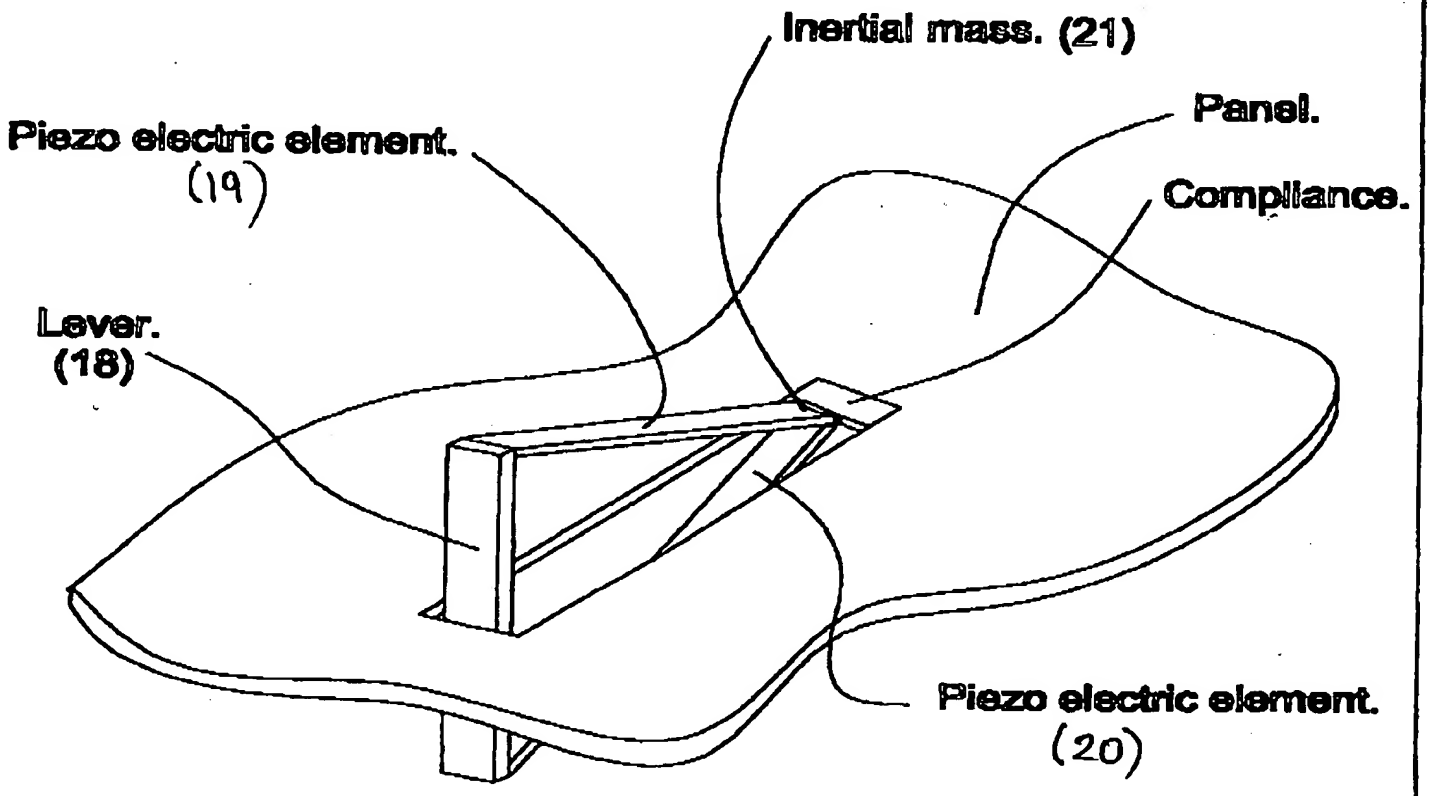


Figure 5b.



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